# XRD analysis of InGaN uniform layers grown on Si (111) without any buffer layers and on Sapphire

Víctor J. Gómez [1], Zarko Gacevic [1], Pavel Aseev [1], Paul E. D. Soto Rodriguez [1], Praveen Kumar [1], Enrique Calleja [1], Richard Nötzel [1] and Miguel A Sánchez [1]

[1] ISOM, Universidad Politécnica de Madrid, Spain

*vjgomez@isom.upm.es*

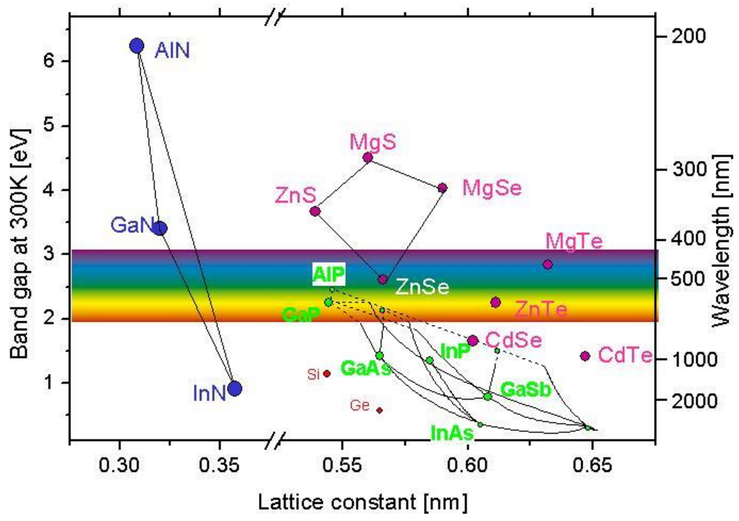
## Motivation

III-nitrides combine:

- Direct and tunable band gap
- High radiation resistance
- High thermal conductivity
- Large absorption coefficient

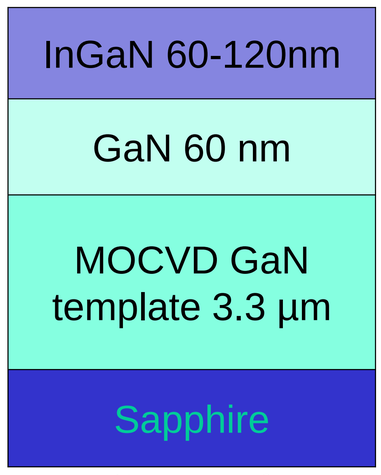
Perfects for:

- Emitters
- Solar cells
- Lasers
- Detectors

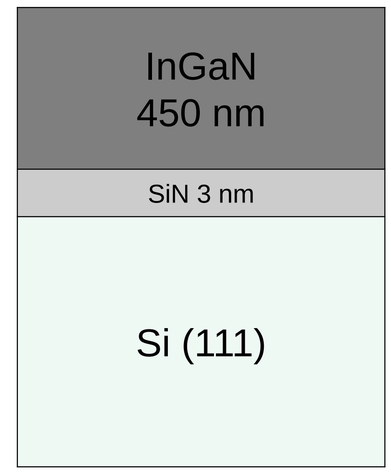



The direct growth on InGaN with various In composition on Si is highly desirable because high band gap buffer layers electrically isolate InGaN from the Si and therefore device design becomes complicated and costly.

## PAMBE growth



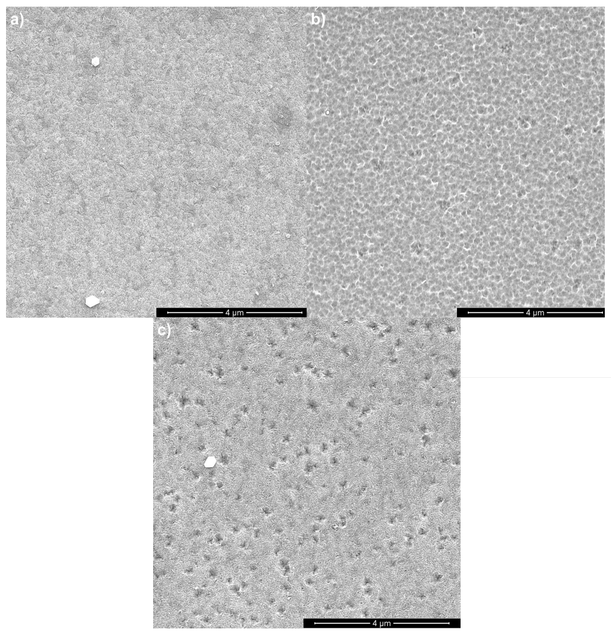

- $\Phi_N$ = 3.7 x $10^{14}$ atoms/($cm^2$.s)
- $\Phi_{Ga}$= 1.75 x $10^{14}$ atoms/($cm^2$.s)
- $\Phi_{In}$ varied between 0.3 and 1.1 x $10^{14}$ atoms/($cm^2$.s)
- $T_g$ = 570ºC




- $\Phi_N$ = 5.7 x $10^{14}$ atoms/($cm^2$.s)
- $\Phi_{Ga}$ varied between 3.9 and 5.2 x $10^{14}$ atoms/($cm^2$.s)
- $\Phi_{In}$ varied between 1.3 and 2.9 x $10^{14}$ atoms/($cm^2$.s)
- $T_g$ = 320ºC

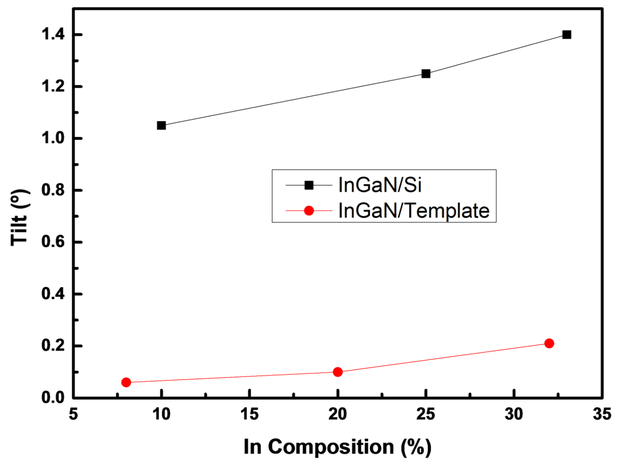


## SEM images




SEM images of the samples grown on Si(111) at 320ºC showing differents In contents 10% for a), 25% for b) and 33% for c).

## X-Ray Diffraction (XRD)

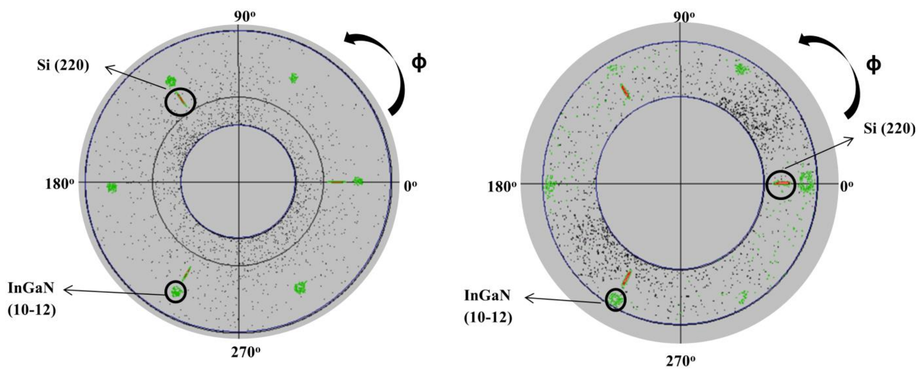



The correlation between tilt and In composition is shown and compared between growth on both substrates.

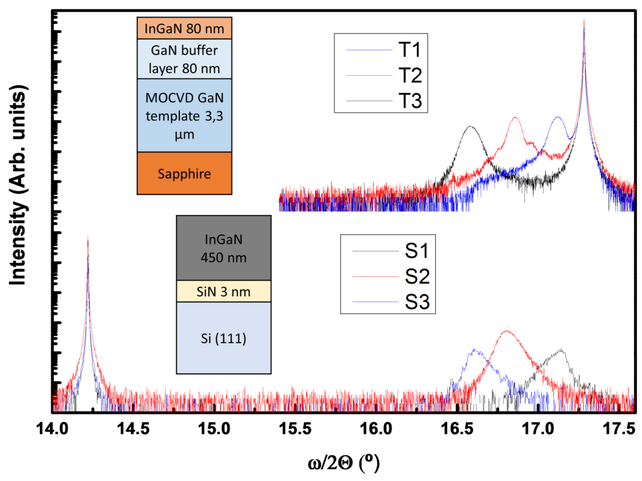
## InGaN Pole Figures

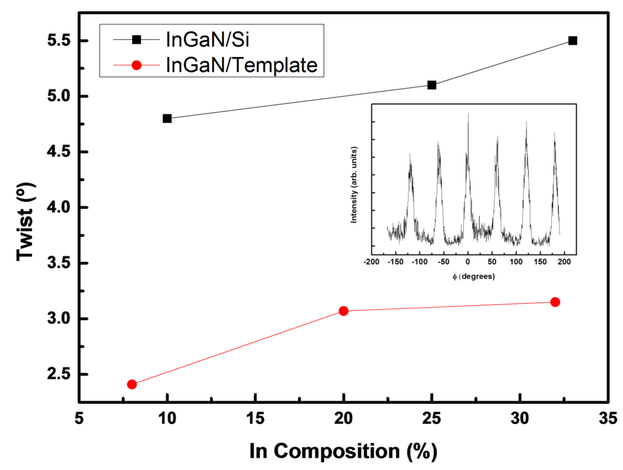
The pole figures for samples with lower and higher In content are represented.

The epitaxial orientation is determined as InGaN(0001)//Si(111) and InGaN[10-10]//Si[11-2].




## X-Ray Diffraction (XRD)

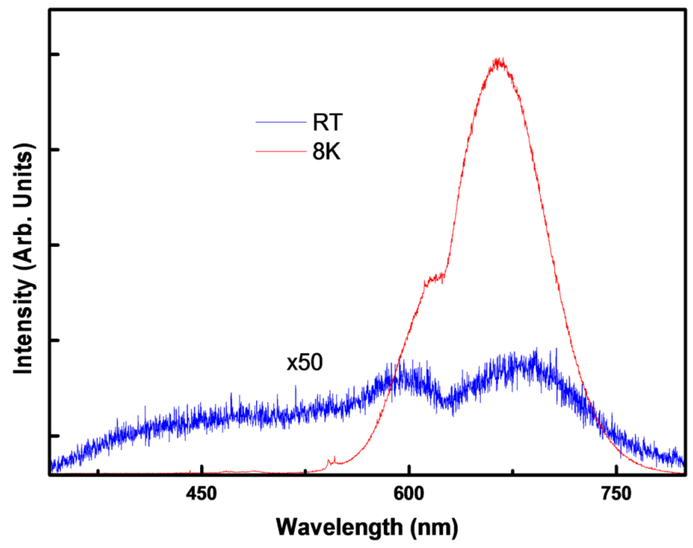



Twist vs composition is shown.

The inset of the shows the φ scan of the sample with higher In content.

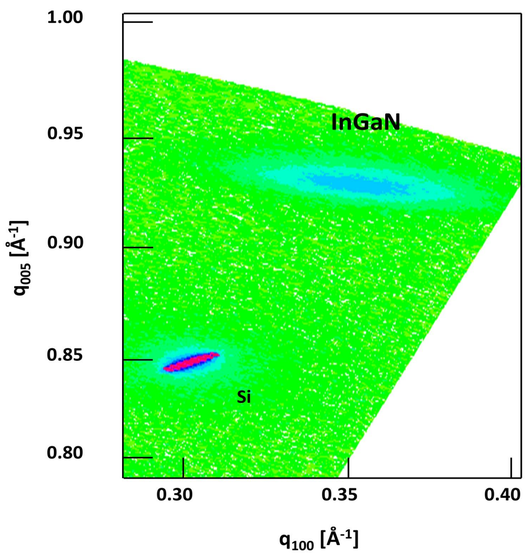
## InGaN PL emision



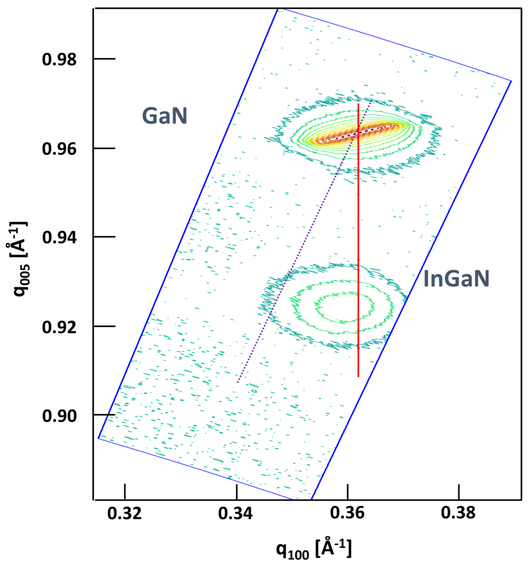

Photoluminescence, up to room temperature, of the sample growth on Si(111) with higher In composition is shown.



## Strain analysis




RSM sample grown on Si with higher In content




RSM sample grown on Template with higher In content



## Conclusions

- InGaN layers grown directly on Si(111), without use of any buffer layer, with different In composition were characterized by means of HRXRD.
- Both tilt and twist show similar trend in Si and in GaN templates. Being higher for samples grown on Si.
- Pole figures show clearly the epitaxial relationship, demonstrating that the InGaN grows epitaxially on Si (111) with the epitaxial relation as InGaN(0001)//Si(111) and InGaN[10-10]//Si[11-2].
- Samples grown on Si were found to be relaxed in average. Samples grown on templates are highly strained.

## Acknowledgements

The work was partly supported by the Spanish Ministry of Science and Innovation, project MAT2011-26703 and ETSIT UPM. P.K. acknowledges a Marie Curie Fellowship from the EC.